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Case study

Clinical and radiographic features of hybrid surgery for the treatment of skip-level cervical degenerative disc disease: A minimum 24-month follow-up

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ABSTRACT

We describe the radiographic changes of IS and investigate the safety and feasibility of hybrid surgery (HS) coupling cervical disc arthroplasty (CDA) and anterior cervical discectomy and fusion (ACDF) for the treatment of skip-level cervical degenerative disc disease (CDDD). Twenty-seven patients who received HS were retrospectively reviewed. Clinical evaluation based on the Japanese Orthopedic Association (JOA) and Neck Disability Index (NDI) and Visual Analog Scale (VAS) scores. Radiographic parameters included cervical alignment (CA), functional spine unite (FSU) angle of intermediated segment (IS), range of motion (ROM) and intervertebral disc height (IDH). Data regarding radiographic changes at IS were collected. The mean follow-up duration of 30.10 months. Compared with preoperative value, JOA, NDI and VAS scores significantly improved after surgery ($p < 0.05$). The CA was recovered significantly after surgery ($p < 0.05$). There was no significant difference in the FSU angle and the IDH of IS between before and at 24 months postoperatively ($p > 0.05$). The ROM of IS significantly decreased at the first week after surgery ($p < 0.05$), was similar to preoperative value at 3 months postoperatively and significantly increased after 6 months ($p < 0.05$). Radiographic changes at IS were observed in 2 patients and Class II Heterotopic ossification (HO) was detected in 2 patients. HS is a safe and feasible alternative procedure for the treatment of skip-level CDDD. It preserved the IS intact and achieved satisfactory clinical and radiographic outcomes over a 24-month follow-up.

1. Introduction

Skip-level cervical degenerative disc disease (CDDD) is regarded as a special multilevel CDDD, which is a rare pathological condition that two noncontiguous segments develop disc degeneration leading to cervical myelopathy and/or radiculopathy while the intermediate segment (s) is actually normal. Anterior cervical discectomy and fusion (ACDF), as a standard surgical procedure, has been widely accepted surgical strategy for the treatment of CDDD [1]. Although ACDF obtained satisfactory outcomes, this procedure obviously altered the biomechanical environment of the cervical spine. Due to loss of mobility at operated level, the range of motion at adjacent level significantly increased as a compensation and the biomechanical stress on adjacent level also considerably increased which was a major contributing factor for acceleration of adjacent segment degeneration (ASD) [2]. Additionally, multilevel ACDF caused higher nonunion rate [3], increased risk of pseudarthrosis and even sacrificed the intermediated normal segments for preventing the possible ASD at these levels. Cervical disc arthroplasty (CDA) has the ability to maintain the intervertebral disc height (IDH) and preserve the physiological motion patterns at operated level after surgery, which theoretically reduce or delay the onset of ASD [4]. In recent decades, CDA has always been counted as an alternative procedure to fusion in single-level CDDD. However, application of multilevel CDA for the treatment of skip-level CDDD is poorly understood. Furthermore, noncontiguous disc disease is often accompanied with severe spondylosis that may restrict the application of CDA.

Hybrid surgery (HS), a relatively new technique that combines CDA with ACDF potentially reduces shortcomings of multilevel CDA while preserve cervical mobility and avoids the flaws of multilevel ACDF. Due to different serious extent of diseased levels, it is rational to choose the optimal procedure according to status of each level. To date, little information is available with respect to optimal surgical procedure for the treatment of multilevel CDDD,

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especially for skip-level CDDD. The current study was designed to focus on the radiographic changes of IS, investigate the safety and feasibility of the HS coupling Prestige-LP prosthesis (Medtronic Sofamor Danek, Memphis, Tenessee) and Zero-P implant (Synthes, Oberdorf, Switzerland) for the treatment of skip-level CDDD, and it is expected that our experience will provide surgeons with an alternative surgical strategy for skip-level CDDD.

2. Methods

2.1. Patient population

From January 2013 to May 2014, 27 patients who received HS were retrospectively reviewed. All patients enrolled in the study were diagnosed of CDDD with symptomatic radiculopathy and/or myelopathy at 2 noncontiguous levels (one or two ISs) from C2 to T1. The primary exclusion criteria for CDA included single-level CDDD or contiguous multilevel CDDD requiring for surgery, prior cervical spine surgery, previous trauma to the C2-T1 levels, radiographic confirmation of severe facet joint disease, obvious cervical instability (i.e., more than 3 mm translation or 20° angular motion at the index level) or loss segmental mobility (i.e., less than 2° range of motion) on radiographs. Osteoporosis, rheumatoid arthritis, diabetes mellitus or any other metabolic disease as well as cancer were considered further exclusion criteria. ACDF was done at the level with dynamic instability and severe disc degeneration. All the patients had preoperative cervical plain radiographs, computed tomography (CT) and magnetic resonance imaging (MRI) for appropriate surgical indication.

2.2. Surgical procedure

All operations were performed by the same senior spine surgeon. After general anesthesia induction and well positioned, a standard right-sided anterior cervical approach and exposure was used in patients. Complete discectomy and decompression was performed firstly at both index levels with removal of the disc tissue, posterior longitudinal ligament and osteophytes. Secondly, for arthroplasty, the endplates and disc space were well prepared by using a burr, the trail, Implant Trail and the Rail Cutter Guide. Next, the proper size of Prestige-LP was inserted along with channels in the endplates. Thirdly, for fusion, after determination of the appropriate size of trail spacer, a corresponding Zero-P implant packed with β-tricalcium phosphate or local excised bone was inserted into well prepared intervertebral space. Next, tightening four locking screws cranially and caudally to fix up the implant. Then the C-arm fluoroscopy was taken to assist to certify the proper placement of the implants. During the operation, the natural structure and prevertebral tissues of the skipped level were preserved. Finally, a drain was inserted before closure of the incision.

For the first 3 weeks, all the patients were encouraged to do neck function training on six directions with the instruction of the doctor. From 3 weeks to 3 months, all the patients were advised to wear a neck collar.

2.3. Data collection

An attending spine surgeon, blinded to patients' clinical conditions and not involved in the surgical procedures, assessed. The collected data included patient demographics, surgery parameters, clinical and radiographic outcomes. The evaluations of the clinical outcomes included Japanese Orthopedic Association (JOA) score, Neck Disability Index (NDI) scores, and Visual Analog Scale (VAS) scores. JOA was used to evaluate the myelopathic status, NDI was used to evaluate the neck function, and VAS was used for assessment of neck and arm pain intensity.

The radiographic parameters included cervical alignment (CA), functional spinal unite (FSU) angle of IS, range of motion (ROM) of C2-C7 and local segments, intervertebral disc height (IDH). The CA was measured using Cobb's angle method between the inferior margin of the C2 vertebra and the inferior margin of the C7 vertebra in a neutral position. The ROM of C2-C7 was defined as the difference in Cobb's angle between the full flexion and extension in lateral radiographs. The FSU angle was formed by lines drawn at the superior endplate of the cephalad vertebral body and inferior endplate of the caudal vertebral body. The ROM of local segments was defined as the sum of the FSU angle, which was measured in full flexion and extension at both operated and skipped levels. Lordosis is shown as a positive value, while kyphosis is shown as a negative value. The IDH was measured as distance between the mid-point of the lower endplate of the cephalad vertebral body and the mid-point of the upper endplate of the caudal vertebral body in lateral radiographs. Measurements on radiographs were performed with ACDSee Canvas 12 software (ACD Systems, Seattle, Washington). The clinical and radiographic data were collected before surgery and at routine intervals of 1 week, 3, 6, 12 and 24 months after surgery.

The radiographic changes were assessed as following [5,6]: 1. new anterior or enlarging osteophyte formation; 2. increase or new narrowing of disc space defined as 33% ≤narrowing of the intervertebral disc space; 3. calcification of ALL; 4. endplate sclerosis. The evaluation of fusion was according to Bridwell classification [7]. Heterotopic ossification (HO) was evaluated on lateral radiographs in accordance with the McAfee classification [13]. Other complications including hoarseness, dysphagia, hematoma, cerebral fluid leakage, device subsidence and device migration were collected.

2.4. Statistical analysis

SPSS 19.0 was used for statistical analysis. Differences were considered significant at a p value of $p < 0.05$. Quantitative data were expressed as the mean ± standard deviation (SD). A paired *t*-test was used to compare between preoperative and postoperative parameters.

3. Results

3.1. Demographics and surgery parameters

A total of 27 patients (16 men and 11 women, respectively) were included for analysis in the current study. The mean age of the patients was 48.11 ± 6.62 years, and the mean follow-up duration of 30.10 ± 7.93 months. The mean operative time was 132.15 ± 36.10 min, and the mean blood loss was 97.50 ± 73.76 ml (Table 1). 24 of these patients presented with single IS, while 3 of them with two ISs. The distribution of the operated levels was C3/4 for arthroplasty and C5/6 for fusion in 16 cases, C5/6 for arthroplasty and C3/4 for fusion in 4 cases, C4/5 for arthroplasty and C6/7 for fusion in 3 cases, C3/4 for arthroplasty and C6/7 for fusion in 2 cases, C7/T1 for arthroplasty and C5/C6 for fusion in 1 case, and C3/4 for arthroplasty and C5/6, C6/7 for fusion in 1 case (Table 1).

The image of typical cases was presented in Fig. 1.

3.2. Clinical outcomes

Compared with preoperative value, JOA score significantly improved at each time point ($p < 0.05$; Table 2). The NDI score and VAS score showed a significant decrease after surgery and